Quasars—Three Years Later

Dewey B. Larson, March 1974

Three years have now passed since publication of the book *Quasars and Pulsars* in which a detailed explanation of the existence and properties of the quasars was derived by pure reasoning from the properties of space and time as postulated in what is known as the *Reciprocal System* of physical theory. In the meantime further observations of these objects have been made, hypotheses and conjectures of all sorts and descriptions have been proposed, tested and discarded, and the astronomers and others concerned have had additional time to assess the significance of the various bits of knowledge that have been accumulated, and to weigh the attempts at explanation of the phenomena more carefully. It would appear, therefore, that it is now in order to take a look at the question as to how well the theory outlined in *Quasars and Pulsars* has been able to cope with the new information developed during the three year period, and where this theory now stands in comparison with the more conventional views of the subject matter.

It was generally conceded three years ago that in the light of orthodox physical and astronomical theory as it then stood the nature of the quasars could legitimately be characterized as a mystery. The present situation is summed up by Cyril Hazard and Simon Mitton in an article in the *New Scientist* of Nov. 29, 1973 as follows:

> After a decade of astonishing progress for astronomy... quasars still remain the profoundest mystery in the heavens.

Nor is there any indication, according to these authors, that the dawn is breaking. On the contrary, their article is entitled “The Deepening Quasar Mystery.”

The explanation presented in *Quasars and Pulsars* requires a change in the fundamental concepts underlying physical theory, and for that reason most astronomers have thus far been reluctant to accept it, but the continuing inability of conventional theory to keep pace with the new observational discoveries, or even to make any appreciable progress toward resolution of the most basic issues that are involved (“a decade of observation,” says *Science News*, “has led to no agreement as to what they (the quasars) are or where they are”) suggests that the time has now arrived when more serious consideration should be given to a theory that accomplishes what conventional theory has been unable to do. When viewed in the light of the new theory there is no mystery about the quasar phenomena. *Quasars and Pulsars* provided an account of the origin, nature, and characteristics of the quasars that was in full accord with all of the information that was available at the time of publication. The objective of the present discussion is to show that the additional knowledge in this area that has been gained in the intervening three year period is equally consistent with the new theory, and puts it in a still stronger position vis-a-vis those portions of current thought with which it is in conflict.

The basis of the new theoretical development is an entirely new concept of the nature of the physical universe. Current physical thinking assumes a universe of matter: one in which the fundamental entities are elementary units of matter existing in a framework provided by space and time. But we now know, definitely and positively, that this assumption is wrong, because we have found means whereby matter can be converted into non-matter and vice versa. Obviously, this shows that matter is not basic. There clearly must be some common denominator underlying both matter and non-matter. Most of the present-day “laws” and “theories” of physical science are based on empirical rather than purely theoretical foundations, and these are not affected by errors in fundamental concepts, but to the extent that current physical thought reasons from theoretical premises it is resting on a false foundation. This is a weakness that is certainly serious enough to account for the inability of present-day theories to meet the demands that are now being placed upon them, particularly in the astronomical field.

The premise on which the new theoretical development is based is that the common denominator, the fundamental entity from which all physical existences and phenomena are derived, is *motion*. The concept of a universe of motion is not, in itself, a new idea, but this work, for the first time, has postulated a universe composed *entirely* of motion—one in which even space and time have no significance other than their status as aspects of motion. When the properties of space and time are specifically defined on this basis they constitute a set of assumptions from which a potentially complete theoretical universe can be derived by purely deductive processes without making any supplementary assumptions of any kind, and without bringing in anything from observation. All of the conclusions reached in the theoretical development, including those with respect to the origin and properties of the quasars that were set forth in *Quasars and Pulsars* are therefore implicit in the fundamental postulates of the theory. If the postulates are valid, then quasars must *exist*, and they *must* have certain specific properties.

The question as to how a theory stands up when confronted with new additions to observational and experimental knowledge is very significant. Indeed, one of the most serious criticisms of current physical theory is that it is continually being faced with new discoveries which it did not anticipate, and with which it cannot cope without replacing or drastically modifying some of its components, an expedient that is feasible because current theory is not a single integrated structure of thought. Rather, as described by Richard Feynman, it is “a multitude of different parts and pieces that do not fit together very well,” and when one of these parts or pieces is found to be in conflict with new observational information the standard practice is to alter or replace it. But a purely deductive and fully integrated theory such as the Reciprocal System cannot be modified to agree with new observations. Such a theory can be *extended* into areas that were not previously covered, or it can be *corrected* if an error in the chain of deductions is found, but it cannot be *altered* to fit the empirical data. Consequently, when this new theory does agree with all of the new information, or at least is not inconsistent with any of it, as has been true in the quasar field during the past three years, this fact has more then the usual significance.

To a large degree, the center of attention in the three-year period has been the question as to the location of the quasars. At the time *Quasars and Pulsars* was published the consensus was strongly in favor of the “cosmological” hypothesis which holds that the quasars are actually at the full distance indicated if their redshifts are wholly due to the Doppler effect of the normal recession, and the dissenters, spearheaded by Dr. Halton Arp of the Hale Observatories, were fighting what appeared to be a losing battle. In the meantime, however, the momentum has shifted to some extent, and the article in the *New Scientist* quoted earlier includes this statement: “The latest quasar results... question further the conventional attitude to the redshift.” This questioning was much in evidence at the Canberra meeting of the International Astronomical Union in August 1973. As reported in the November issue of *Sky and Telescope*, “The most controversial subject was the interpretation of the galaxy redshifts, which a growing minority of astronomers believe are not a simple distance effect.”

But when we examine the evidence bearing on the question, there is actually nothing *definite* anywhere except the work of Arp that was analyzed in *Quasars and Pulsars*. All of the other reported findings, with two exceptions that will be discussed later, consist of agreement or disagreement, as the case may be, between the redshifts of objects whose projections on the sky are close enough to indicate that these objects *may* be contiguous. As a general proposition, a finding of this kind, a showing that *some* of the members of a given class conform to a specified relation, has little significance. It remains no more than speculative unless further work enables defining a sub-class such that *all* of the members of this subclass conform to the specified relation.

The reason why the results obtained by Arp are conclusive, whereas the other findings are not, is that Arp has done what no one else has been able to do; that is, he *has* defined a class of objects, all known members of which *do* conform to a definite and specific redshift relation. In the course of his studies of "peculiar" galaxies he found that certain galaxies which appear to have been subject to violent internal forces are bracketed by one or more pairs of radio emitting objects—quasars or radio galaxies—at distances and locations which suggest that these objects were ejected simultaneously in opposite directions from the disturbed central galaxies. These associations are not merely groups of objects whose observable positions indicate that they *may* be neighbors. They are groupings whose physical characteristics are similar and are in agreement with a plausible hypothesis as to their origin; that is, their identification depends not only on apparent proximity, but also on (1) abnormalities in the central galaxy (which are consistent with the assumption that it has exploded), (2) radio emission from the presumed ejecta (which is consistent with the assumption that they are products of an explosion), and (3) existence of the presumed ejecta in pairs at comparable distances and in positions on opposite sides of the central galaxy (which is consistent with the assumption that they were thrown off simultaneously in opposite directions).

Dr. Arp did not pursue the redshift issue in the original study beyond commenting that the existence of associations between quasars and ordinary galaxies makes it evident that there is a component in the quasar redshift in addition to that due to the normal recession, a non-velocity component, he suggested. Subsequently the redshift data available for these associations were analyzed by the present author, and the results of that analysis were presented in *Quasars and Pulsars*. As shown in that publication, complete redshift measurements were available for four of those associations identified by Arp that included quasars. Within a narrow range of variation that can be accounted for by known causes of deviation, the mathematical relation between the central galaxy redshift and the redshift of the quasar is identical in *all four* of these cases. In view of the wide dispersion of the values of the quasar redshifts in general, the probability that the redshift of any one quasar would fall within the relatively narrow range of deviation is less than one in a hundred. The probability that all four would, by chance, conform to the same mathematical relation within this range of deviation is therefore in the order of one in a million.

But this is not the whole story. Beyond the distance at which the features of the central galaxy can be identified with certainty (according to Arp) it has still been possible to locate probable associations of the same kind in which measurements of the redshifts of the quasars and the radio galaxies can be compared. The necessary data are available for three such associations in which the redshift is approximately 1.00, and here again *all three* of the associations conform to the *same* mathematical relation between member redshifts that applies to the closer groups. The only discrepancy found anywhere in the analysis was in the data for the most distant grouping for which the redshifts are available, one in which the quasar redshift is 1.66, and since this is well beyond the limit of positive identification as an association of related objects we can legitimately disregard it. When the three associations in the neighborhood of redshift 1.00 are added to the first four, the probability that the agreement between the redshift relations in all of the groups is accidental drops to about one chance in a billion. The results of the analysis thus verify the reality of the associations and furnish *definite proof* that there is a specific mathematical relation between the redshift of a quasar and the normal recession redshift of an ordinary galaxy or radio galaxy at the same spatial distance as the quasar.

Furthermore, these results show that the additional redshift component which is present in the quasar redshift is due to *some physical mechanism that is specifically related to the normal recession*. The existence of two distinct components makes any hypothesis such as that of "tired light" untenable, while the fixed mathematical relation between the two components rules out anything such as a redshift of gravitational origin which is independent of the recession. Here, then, is a case where astronomical observations unequivocally demand something that conventional physical theory cannot supply. This is not the kind of a situation so common in astronomy in which the observations merely *suggest* certain conclusions; the results of this analysis are specific and positive.

As many prominent astronomers concede, the general lack of progress toward an understanding of the quasar phenomena is a clear sign that a revision of basic ideas is necessary. Now the redshift analysis identifies some of the specific features that an adequate theory must possess. It must provide some mechanism whereby galaxies explode and eject quasars; it must provide some explanation as to why the redshifts of these quasars include a component related to, but distinct from, the normal recession redshift; it must provide a means whereby this second component can be produced; and it must arrive at the precise mathematical relation between the two classes of redshifts that exists in the Arp associations.

All of these requirements are met by the quasar theory derived from the fundamental postulates of the Reciprocal System. The features that the observations demand are the *same* features that we find when we apply pure reasoning to the properties of space and time as defined in the postulates. A development of the necessary consequences of these properties, without introducing anything from empirical sources, leads directly to the existence of matter, and on further extension to the existence of the aggregates of matter—stars, galaxies, etc.—that are the concern of astronomy. A continuation of the chain of reasoning shows that matter is subject to certain processes which in the course of time eventually culminate in explosive disintegration, resulting in phenomena observationally recognized as Type II supernovae. Further development of theory reveals that these supernova explosions occur mainly in the interiors of the oldest and largest galaxies and build up the equivalent of a pressure in these structures. When the pressure exceeds the restraining force the galaxy explodes, ejecting at least two fragments in opposite directions, one or more at a speed less than that of light, and one or more with a speed greater than that of light. However, the ultra-high speed fragments are subject to gravitation in the same manner as any other material aggregates, and their net effective speeds are therefore less than that of light for a considerable period of time, during which a fast-moving galactic fragment is observable as a quasar.

The explosive event which is required by the theory produces exactly the kind of an association of three related objects—a central galaxy with a radio galaxy on one side and a quasar diametrically opposite—that Arp has identified in his studies. The ultra-high speed imparted to the quasar by the tremendous energy released in the galactic explosion results in an additional dimension of motion, producing a second redshift component, related to, but distinct from, the normal recession, as required by the observations, and the mathematical statement of that relation as derived from theory is identical with the relation between the measured values.

As brought out in *Quasars and Pulsars*, this one-to-one correspondence between the theoretical deductions and the observational results is maintained throughout the entire range of the quasar phenomena. In this connection, it should be noted that the difficulties which conventional theory is having with the quasars—those difficulties that have made "quasar" almost synonymous with "mystery"—are not due to a lack of knowledge about these objects, but to too much knowledge. It is easy enough to fit a theory to a few bits of information, and the scientific community currently claims to have a sound theoretical understanding of a number of phenomena about which very little is actually known. But, as Harlow Shapley remarked some years ago, facts are the number one enemy of theories, and a great many facts about the quasars have been accumulated. As a consequence, orthodox theory is currently in a position where any explanation that is devised to account for one of the observed features of the quasars is promptly contradicted by some other known fact. Against this background, the complete agreement between the new theory and the observations is all the more meaningful.

Some of the features of the account of the origin and nature of the quasars derived from the Reciprocal System of theory are in conflict with current thought, to be sure. For example, present-day theory sees no way in which the forces necessary to eject a galactic fragment can be built up within a galaxy. "Obviously a normal assemblage of stars cannot be hurled about like a snowball," says Arp. But this merely reveals a weakness in current thought, as the observational evidence now available makes it almost certain that fragments are ejected under some circumstances; that is, they are hurled about like a snowball. Current astronomical literature is full of references to, and hypotheses dependent upon, ejection of "assemblages of stars" from galaxies. In explaining how this is possible, and indeed inevitable in the normal course of galactic evolution, the Reciprocal System is simply filling an existing conceptual vacuum.

Similarly, current scientific thought rejects the possibility of speeds in excess of that of light, although the investigators who are studying the "tachyon" hypothesis are questioning this dictum because they recognize the same point that became evident in the course of the present study; that is, the limit is imposed by *theory*, not by established facts. The only factual evidence available simply shows that a greater speed cannot be imparted to a material object *by a particular kind of a process*. This evidence does not indicate whether the observed limitation applies to the possible speed or to the capabilities of the process, and the conclusions of the Reciprocal System, which support the latter view, are equally as consistent with the evidence as the currently favored interpretation. When the observations from other areas are examined carefully it will likewise be seen, as in the foregoing examples, that the conclusions reached by the new theory are consistent with all of the definitely established facts, even though some of them are in conflict with currently accepted theories or assumptions.

For the benefit of those who are reluctant to take such a seemingly drastic step as giving credence to a theory which involves motion at speeds greater than that of light, it may be well to point out that as long as *some* major change in basic theory is required in order to bring it into harmony with present-day knowledge—a need that is now widely recognized in astronomical circles, and has been definitely confirmed by the redshift analysis just discussed—the kind of a change that will disturb existing physical ideas the least is one such as this which applies only to the far-out regions in which difficulties of one kind or another are being experienced. Of course, in the long run there is no choice. Physical theory must conform to the way in which the universe actually behaves, whatever that may be. But for those who dislike making major changes there may be a certain amount of consolation in the fact that while the introduction of ultra-high speeds into the theoretical structure, as required by the concept of a universe of motion, revolutionizes our view of some of the less familiar phenomena such as the quasars, it leaves the great bulk of physical theory untouched.

As mentioned earlier, there have been two recent attempts to confirm the cosmological hypothesis as to the location of the quasars by means other than comparing the redshifts of presumably associated objects. One of these was by Bahcall and Hills (*Astrophysical Journal*, Feb. 1, 1973), who compared redshifts with brightness and arrived at results that were summarized in a news report as follows: "The point is simply that, by and large, quasars with large redshifts seem dimmer than those with small redshifts, just as we would expect if they are farther away." This is, of course, valid evidence against the "local" hypothesis, which asserts that the quasars are in, or have been ejected from, our own or some nearby galaxy, but it does not favor the cosmological hypothesis over the "intermediate" explanation arrived at observationally by Halton Arp and theoretically from the postulates of the Reciprocal System. On this intermediate basis the quasars with large redshifts *are* farther away—*much* farther away—even though not nearly as far away as the cosmological hypothesis would put them.

While the controversy over the related subjects of the nature of the quasar redshifts and the location of these objects in space has occupied the center of the stage during the past three years, the discovery of a number of additional quasars with very large redshifts is actually more important, both as a significant increase in observational knowledge and as a further confirmation of the theoretical conclusions reached by application of the Reciprocal System of theory.

At the time the book *Quasars and Pulsars* was published, only one quasar redshift that exceeded the normal limit of 2.326 by any substantial amount had been reported. As pointed out in that work, the 2.326 redshift is not an absolute maximum, but a level at which conversion of the relative motion of the quasar to a different status, which it will ultimately assume in any event, *can* take place. Hence the very high value, 2.877, attributed to the quasar 4C 05.34 either indicated the existence of some process whereby the conversion that is theoretically able to occur at 2.326 is delayed, or else was an erroneous measurement. Inasmuch as no other data bearing on the issue were available it did not appear advisable to attempt to decide between the two alternatives at that time.

In the meantime some additional quasar redshifts above the normal limit have been measured, and the theoretical situation has been clarified. The new measurements give redshifts of 2.69, 3.40, and 3.53, for the quasars PHL 957, OH 471, and OQ 172, respectively. These observations confirm the existence of redshifts in the range between 2.326 and the absolute maximum, and the fact that all of the high values are *much* above the normal limit points at once to the nature of the process that is involved.

Because quasars with lower redshifts are less distant and therefore more readily detected, other things being equal, a quasar with a redshift only moderately above 2.326 is more likely to be found than one with a redshift much above this figure, if there is a continuous distribution of redshifts throughout this range. The fact that the only ultra-high redshift known in early 1971 was far above any value previously measured was merely suggestive of some departure from a continuous distribution, but when the next three discoveries also involved redshifts substantially above the normal limit it became rather obvious that these unexpectedly high values were not chance results. The maximum normal redshift can be increased slightly above 2.326 by random motion in three-dimensional space superimposed on the motions of the recession type to which the 2.326 limit applies, and the tabulation by Burbidge and O'Dell, *Astrophysical Journal*, Dec. 15, 1972, lists two such values, 2.36 and 2.39, for the quasars 4C 25.5 and 5C 02.56, respectively. The latter is apparently a rather peculiar object, and its redshift may be abnormal, but in any event, its excess of about .06 is probably close to the maximum that random motion can be expected to contribute. The observational data now suggest that there are no redshifts at all in the range just above 2.39; that is, the process which enables the recession to exceed the normal limit involves a jump to a considerably higher redshift level.

On this basis a continuation of the normal z + 3.5 redshift pattern beyond 2.326 is ruled out, and a process that modifies the 3.5 coefficient of the second redshift component is required. Once we arrive at this conclusion it is immediately obvious how this modification can occur. It should be understood that the change which takes place at what has been called the conversion point is not a physical process affecting the quasar itself; it is a change in the observed character of the quasar motion relative to our location in space. Before the conversion point the relative spatial speed of the quasar is less than unity (the speed of light) by reason of the retardation due to gravitation. Beyond that point the gravitational effect disappears, the relative spatial speed assumes the maximum value of unity, and further change of relative position takes place in time only. But since the gravitational effect does not vanish immediately, this is not a knife-edge transition, and the effective spatial speed can therefore exceed the normal limit by a small amount.

An unfamiliar process such as this change in the apparent nature of the relative motion can best be explained by means of an analogy. For this purpose, let us consider the behavior of sunlight at the horizon. Inasmuch as light is normally propagated in straight lines, the horizon constitutes a limit (analogous to the 2.326 redshift) beyond which the sun disappears from *our* view (analogous to the disappearance of the quasar when the spatial speed reaches unity) if the light continues to move in the normal straight line pattern. But under certain circumstances, the light is refracted by the atmosphere, and by virtue of this refraction process (analogous to the special conditions that exist at the 2.326 limit) we are able to see the sun for a limited period of time after it sinks below the horizon (this is analogous to being able to observe a quasar for a limited time, and distance, beyond that corresponding to the 2.326 redshift).

This additional recession beyond the normal limit necessarily involves an increase in the second term of the quasar redshift expression. But the quantity $3.5z^{½}$ cannot exceed 2.00, for reasons explained in *Quasars and Pulsars*, and the required increase in this term must therefore be accomplished by a change in the numerical coefficient. This coefficient is not fixed; the normal value 3.5 is merely the result of probability considerations which divide a total of 7 equally between the two dimensions of the explosion-generated motion. When some other factor intervenes, such as the arrival at the 2.326 limit, where the only alternative to disappearance of the quasar is alteration of the probability distribution, the latter takes precedence; that is, when we can no longer see the quasar in the usual manner, if there is any other way in which we can see it, we will do so. Instead of the normal 3½-3½ distribution, the division then becomes 4-3, 4½-2½, 5-2, etc. This is the inverse of the modification of the distribution of the 7 total units which gives rise to the absorption redshifts of the quasars that are still below the 2.326 limit. In that case the effective factor is reduced below the normal 3½ value to enable the quasar to absorb more energy in a greater speed, whereas in the situation now under discussion the factor is increased above the normal 3½ value to enable delaying the conversion to an unobservable state.

On the foregoing basis, the redshift of a quasar follows the regular $z + 3.5z^{½}$ pattern up to the normal limit at 2.326. At that point it jumps directly to a higher value corresponding to a greater distribution factor (hereafter designated as F), the normal recession remaining at .326. The possible redshifts immediately after the readjustment (that is, before any further outward movement of the quasar has occurred) are compared with the observed ultra-high redshifts in the following tabulation. All of the calculated values may be modified to a small degree by random motions of the kind previously mentioned.

Table 1: ULTRA-HIGH REDSHIFTS

F	Calculated (zero z increment)	Observed	Indicated Increment	Quasar
4.0	2.61	2.69	.08	PHL 957
4.5	2.90	2.88	-	4C 05.34
5.0	3.18			

F	Calculated (zero z increment)	Observed	Indicated Increment	Quasar
5.5	3.47	3.40	?	OH 471
	3.47	3.53	.06	OQ 172
6.0	3.75			

After the readjustment it is possible to observe a further slow increase of the redshift (analogous to seeing the sun below the horizon) which results from a continuation of the normal recession only. When this recession increment is large enough (probably somewhere between .05 and .10) it initiates the conversion process and the quasar disappears. In the interim the observed redshifts exceed the tabular values calculated on the basis of a zero increment by the amount of the actual increment.

It should be emphasized that the jump from F = 3.5 to a higher value does not, in itself, involve any increase in distance. For example, a quasar with z = 3.18 (F = 5.0) is at the same location immediately after the readjustment as a quasar with z = 2.326 (F = 3.5). Inasmuch as the subsequent recession increment is limited to a very small amount, it follows that all quasars with z = 2.326 and above are at approximately the same spatial distance. This is the explanation of the seeming inconsistency involved in the observed fact that the brightness of the quasars with ultra-high redshifts is comparable to that of the quasars in the z = 2.00 range.

Although random motions and possible observational inaccuracies introduce some uncertainties, the tabulated figures enable us to draw some tentative conclusions as to the size of the recession increment, and consequently the progress which each of the observed ultra-high redshift quasars has made toward the conversion point. The .08 excess in the observed redshift of PHL 957 suggests that this quasar is quite far advanced and is nearing the point of conversion, whereas the lack of any increment in the redshift of 4C 05.34 shows it to be in an earlier stage, not much beyond the normal limit. OQ 172 is in an intermediate condition, while the status of OH 471 is uncertain.

A further check of redshift theory against observation is possible because absorption redshifts have been measured for two of the ultra-high redshift quasars. On the basis of the theory developed in *Quasars and Pulsars*, the magnitudes of the possible absorption redshifts at zero recession increment can be calculated by replacing the factor F applicable to emission with successively lower values. This mechanism involving a change in F operates in the same manner both above and below the normal 3.5 factor. The theoretical redshifts of the two quasars, calculated in this manner, are compared with the observed values in the following tabulation. Some additional values were reported for PHL 957, but these were characterized by the observers as less than “probable,” and they have therefore been omitted.

Table 2: ABSORPTION REDSHIFTS

F	Calculated	Observed	
		4C 05.34	PHL 957
4.5	2.90	2.88	
		2.81	

F	Calculated	Observed	
4.0	2.61	2.59	2.66
3.75	2.47	2.47	
3.5	2.33		2.31
3.25	2.18	2.18	2.21-2.23
3.0	2.04		2.07
2.75	1.90	1.86	
2.5	1.76	1.78	

The 4C 05.34 measurements (Bahcall and Goldsmith, *Astrophysical Journal*, Nov. 15, 1971) include one value 2.81 for which there is no theoretical counterpart. Aside from this, the correlation with the theoretical figures is very impressive. The other seven observed redshifts agree with the calculated values within an average deviation of less than .02, which is comparable to the close correlation in the figures for the only other equally extensive system thus far located, that of PKS 0237-23, which was discussed in *Quasars and Pulsars*.

There are no unexplained redshifts in the "probable" list for PHL 957. The lower measurements for this quasar agree with the theoretical values within the range of deviation that can be explained by random motions, as is to be expected since there is (by definition) no recession increment at or below the normal limit. The deviation of the one absorption redshift observed in the range between 2.326 and the emission value is about double the average deviation in the lower range, indicating that there is probably a recession increment here, instead of, or in addition to, random motion. This lends support to the conclusion expressed earlier that the .08 excess in the PHL 957 emission redshift is evidence of a recession increment, and that this quasar is therefore in a relatively late stage.

It is also evident that these absorption data confirm the validity of the theoretical explanation of the nature of the ultra-high emission redshifts. The continuity of the absorption redshift pattern all the way from F = 4.5 to F = 2.5 shows that the redshifts above the normal limit do, in fact, result from modification of the distribution factor F in the manner specified, while the agreement between the PHL 957 values and those for 4C 05.34 verifies the theoretical finding that the increase in the normal recession beyond 2.326 is limited to a relatively small increment. The following comment from the Burbidges in their book

Quasi-Stellar Objects (1967) is prophetic:

> We have gone into considerable detail in describing the absorption lines in the spectra of QSO's, because these may in the end provide more clues for solving the problem of the nature of the QSO's than do the emission lines.

One of the reports of observations made on PHL 957 includes the comment that the most striking feature of the absorption spectrum of this quasar, a "very broad line," corresponds to z = 2.309. This is, of course, the normal limiting value 2.326 with a small random motion modification, and it is not surprising that it is prominent. It *is* somewhat surprising, however, that this value does not appear in the list of observed absorption redshifts for 4C 05.34, and it will be of some interest to see if it shows up when further observations of this quasar are made. This absence is all the more striking in view of the presence of so many redshifts at intermediate factors (3.25 etc.). Previous studies of absorption redshifts reported in *Quasars and Pulsars* indicated that these intermediate factors are normally encountered only at the lower end of the range of values (the high energy end). The PHL 957 redshifts conform to this general rule, but the intermediate values are prominent throughout the entire redshift range of 4C 05.34. However, the great spread of these absorption redshifts—all the way from factor 4.5 down to 2.5—shows that this quasar is literally blowing itself apart, and this no doubt accounts for the multiplicity of redshifts, as in such a violent environment almost any possible situation will be realized.

In case there is any question as to why this quasar (4C 05.34) is the one that is apparently nearing the time when it will be so badly disintegrated that it will cease to exist as a physical object, while PHL 957 is apparently the one that has progressed farthest toward the point where its relative motion will convert to the zero time datum and the quasar will become unobservable, it should be explained that two different processes are involved. The ultimate demise of the quasar is simply a matter of *age*. When the great majority of the stars that constitute the fast-moving galactic fragment that we call a quasar have reached the age limit of matter and have individually disintegrated, the quasar ceases to exist as such, irrespective of where it may be at that time. On the other hand, the disappearance of the quasar at the conversion point, the point at which its motion relative to our location in space changes character, is a matter of *distance*, and it is dependent on both the initial location, the scene of the galactic explosion, and on the amount of time during which it has been receding since that initial event. A quasar that originated at a distant location may therefore reach the conversion point in somewhere near its original condition, whereas one that originated nearby may disintegrate before it ever arrives at the point of conversion. The disintegration, unlike the conversion, is a definite physical event. When PHL 957 passes out of our ken it may still be observable from some other galaxies that were closer to the scene when the original explosion that produced this quasar occurred, but when 4C 05.34 is reduced to debris its existence as a quasar will have terminated.

Aside from the measurements on PHL 957 and 4C 05.34, the new absorption redshift data accumulated during the three-year period under consideration have been confined mainly to values comparable to the emission redshifts. However, two measurements that have been reported for the quasar PKS 0812+02 are of special interest because this is the first quasar with a redshift below 1.00 for which a clear-cut comparison of a series of observed absorption redshifts with the corresponding theoretical values could be made. As indicated in the following tabulation, two of the possible steps below F = 3.5 have been activated in this quasar, making it possible to demonstrate more conclusively that the absorption redshift theory which is here being discussed is applicable to the lower redshift ranges as well as to the higher values.

Table 3: ABSORPTION REDSHIFTS - PKS 0812+02

F	Calculated	Observed
3.5		.402 (em)
3.25	.374	.384
3.0	.346	.344

Another new development in the redshift area since the date of the previous publication is the discovery of an absorption redshift in the radiation at radio frequency from the quasar 3C 286. This has generated considerable interest because of an impression in Borne quarters that the radio absorption requires an explanation different from that applicable to absorption at optical frequencies. Brown and Roberts, who made the original observations, conclude that the redshift is due to absorption by neutral hydrogen in some galaxy lying between us and the quasar. Since the absorption redshift is about 80 percent of the emission redshift of the quasar, they regard the observations as evidence in favor of the cosmological redshift hypothesis. (This is the second of the two cases in which attempts have been made to bolster the cosmological hypothesis by means other than the usual correlations between the redshifts of presumably associated objects.)

On the basis of the Reciprocal System of theory the radio observations do not introduce anything new. The absorption process that operates in the quasars is equally applicable, according to that theory, to *all* radiation frequencies, and the existence of an absorption redshift at radio frequencies has the same significance as the existence of an absorption redshift at optical frequencies. Furthermore, the values of the radio redshifts are subject to the same considerations as those of their optical counterparts. The emission redshift of 3C 286 is .849. Calculation by the method explained in *Quasars and Pulsars*, and utilized in deriving the theoretical redshifts earlier in these pages, establishes the first three possible absorption redshifts below the emission value for a quasar of emission redshift .849 as .79, .735, and .68. As the observed value of the radio redshift is .69, the agreement with theory is complete.

At the time *Quasars and Pulsars* was released for publication, the available absorption redshifts, other than those in the immediate vicinity of the emission values, were confined to the range of redshifts which we may call the normal high redshift region, just below the normal limit at 2.326. The results of the comparison between these data and the calculated values were summarized in the book as follows:

> Although the amount of observational information available for correlation with the theoretical deductions is small, the agreement is so close that it constitutes a rather strong case in favor of the theoretical development.

As demonstrated in the foregoing paragraphs, the additional measurements reported during the past few years have enabled extending these correlations to a much wider field—to the ultra-high redshift region beyond the 2.326 limit, to the relatively low redshift region below 1.00, and to the radio frequency region. Inasmuch as the agreement between the theoretical and observed values is equally as satisfactory in these new areas as in the redshift region covered in *Quasars and Pulsars*, the “rather strong case” has become very much stronger. As matters now stand, it is almost as conclusive as the results of the analysis of the redshifts in Arp’s associations. Taken together (and they must be considered together, as they are based on the same conceptual foundations and the same mathematics) they should be decisive.

One of the important results of the application of the Reciprocal System of theory to the quasars is the finding that there are two distinct classes of radio-emitting quasars with quite different properties, separated by a long radio-quiet period. The internal activity of a Class I quasar, one that has just recently (in the astronomical sense) been ejected from the galaxy of origin, results mainly from the energy imparted to it by the galactic explosion in which it originated. When this activity subsides the quasar enters the radio-quiet period. Later, its constituent stars begin to arrive at their age limits, and explosions of these stars renew the internal activity. As soon as this is sufficiently energetic, radio emission resumes on the Class II basis.

The most distant quasars now known are all Class II objects, as the Class I quasars are not currently observable at these immense distances. Below a redshift of about 1.00, however, both classes are present, and in order to distinguish one from the other it is necessary to utilize some measurable properties in which there is a systematic difference between the values applicable to the two classes of objects. Ultimately it should be possible to establish such lines of demarcation from pure theory, but for the present this must be done empirically, and tentative criteria were defined in *Quasars and Pulsars* on the basis of the magnitude of the radio flux and the U-B color index. The additional information accumulated in the intervening three years now makes it possible to review this situation with the dual objective of increasing the accuracy of the lines of demarcation between the two quasar classes and at the same time demonstrating the agreement between theory and observation that exists in areas not covered in the earlier publication.

It will be convenient to begin this review with a consideration of the limitations to which the occurrence of absorption redshifts in the quasars is subject. From theoretical premises we have previously deduced that the absorption which gives rise to the absorption lines in the quasar spectra takes place in concentrations of material thrown out in the course of internal explosions in these objects. No absorption exists, therefore, until the explosions occur on a sufficiently large scale. As noted earlier, this point is not reached until the quasar is somewhere in the radio-quiet stage, while it is evident from the nature of the requirements for the production of multiple absorption redshift systems that multiplicity will not appear until a still higher level of activity is reached. On the basis of this evolutionary pattern we can deduce the following rules regarding the occurrence of absorption redshifts:

1. Class I quasars have no absorption redshifts.
2. Absorption redshifts approximating the emission values are possible throughout most of the radio-quiet region, as well as in the Class II quasars.
3. Absorption redshifts differing from the emission values by more than the amount that can be attributed to random motion are possible only in Class II quasars and relatively old radio-quiet quasars.

A review of the absorption redshifts listed in the compilation by Burbidge and O'Dell was carried out for the purpose of testing the validity of these rules. In order to maintain a continuity with the correlations between theory and observation that were presented in the previous publication, the radio and optical data utilized in the current analysis were taken from the same sources as before, and the same limiting values were applied in determining the class of quasar.

On this basis there is no violation of Rule 3, but three of the 29 quasars with absorption redshifts appearing in the reference tabulation are in violation of Rule 1. This is, of course, too large a discrepancy. As stated in *Quasars and Pulsars*, there is a theoretical possibility of some rare exceptions to rules of this kind based on the normal pattern of quasar evolution, because there is a chance that the galactic fragment which is ejected as a quasar may contain a substantial number of old stars, in which case the normal time schedule will be anticipated. One deviant out of the 29 might be explained in this way, but not 3.

Examination of the measured values leads, however, to the conclusion that the difficulty lies in the original criteria by which the two classes of quasars were distinguished. The radio emission and color measurements (with one value missing) indicate that all three of the doubtful quasars are similar in their characteristics; that is, all three are in the region of high U-B values and low radio emission. This suggests that while the line of demarcation between Class I and Class II shown in the diagrams in *Quasars and Pulsars* is probably somewhere near correct in the low U-B region, it needs to be modified in the region of high (more negative) U-B values. Like all other empirical products, this boundary line is subject to change when more information becomes available.

A study has indicated that the necessary adjustment of the selection criteria can be accomplished by introducing the B-V color index into the classification system. (This is equivalent to defining areas on a two-color diagram such as Fig. 2.1 in the Burbidge book *Quasi-Stellar Objects* from which the data used in establishing the original lines of separation were taken.) The available B-V measurements for the three quasars that, on the basis of the presence of absorption redshifts, belong in Class II, are in the upper portion of the full range of values, whereas those of the relatively low redshift quasars in this region, which can be expected to be mainly Class I objects, fall principally in the lower portion of the range. We may tentatively establish a dividing line at +.15, and instead of assigning all of the quasars with low radio emission and high U-B values to Class I, we will put the members of this group that have B-V indexes above +.15 in Class II.

Until such time as we are able to base the selection criteria on a theoretical rather than an empirical foundation we can hardly expect precision, but the change to two-color standards undoubtedly brings us closer to the correct line of demarcation, as all of the quasars with absorption redshifts now fall in Class II, as required by theory, whereas all but one of those in the region under consideration that have emission redshifts below .350 fall in Class I, as most of them theoretically should. The importance of being able to distinguish between the two classes of quasars on the basis of the color indexes and radio emission lies in the fact that this makes it possible to check the validity of the theoretical conclusions that are reached with respect to other features of these objects, such as the rules with respect to the occurrence of absorption redshifts. After the criteria are changed as indicated above, the 29 quasars in the reference list are all in conformity with the rules as stated.

This successful use of the B-V color index to improve the distinction between the two classes of radio-emitting quasars in the region in question naturally suggests extending consideration of the behavior of this index to an examination of the entire pattern of the variations that take place during the course of evolution of the quasar, a subject that was not investigated in the study that produced the results reported in *Quasars and Pulsars*. It was mentioned by the Burbidges that the astronomers recognize a systematic, but “rather complicated” relation between the spectral colors of the quasars and their redshifts. Theoretical considerations indicate that the true relation is between color and internal activity. The internal activity of an average quasar of each class is a function of its age, and the average age, in turn, is related to the distance. Thus there is a theoretical basis for the astronomers' finding; that is, there actually is a somewhat loose relationship between the color indexes and the redshift (distance).

The principal reason for the “rather complicated” nature of the relations indicated in the Burbidge Figs. 4.4 and 4.5 is the lack of differentiation between the two classes of quasars. When the classes are separated, most of the complexity disappears, although there is still a large scatter of the values because the relation between color and redshift is indirect and only approximate. The correlation between age and distance depends on the fact that the quasars are continually moving outward, but explosive ejections occur at distant, as well as nearby, locations, and individual quasars may therefore be considerably younger than the average quasar at the same distance. In Class I there are also variations in internal activity due to differences in the magnitudes of the galactic explosions in which the ejections took place, while in Class II both the time of onset of the secondary explosions and their rate of development are variable. Nevertheless, there is a definite general pattern. “The systematic nature” of the color-distance relation, say the Burbidges, “is apparent.”

The U-B index was discussed in *Quasars and Pulsars*. As brought out there, the initial range of this index immediately following ejection is from -.40 to -.50. As these Class I quasars age, the index gradually moves toward values in the range from -.75 to -1.00. No systematic variation of this U-B index was found in the Class II quasars.

The B-V indexes of the earliest Class I quasars that have been observed are in the range from +.40 to +.60. Like the U-B index, the B-V value gradually moves in the negative direction with increasing age, and those quasars that are approaching the radio-quiet stage have indexes below +.10, extending to negative values in some instances. The B-V index for most of the Class II quasars with relatively low redshifts (below .750) are in the neighborhood of +.20. Beyond .750 the index increases, and maximum values around +.60 are reached between 1.00 and 1.40 redshift. This maximum is followed by a rather rapid drop to a level in which most values are comparable to those of the early members of this class.

While the actual mathematical relation between the internal activity of the quasars and their color indexes has not yet been examined from the standpoint of the Reciprocal System of theory, the pattern followed by the values of these indexes, as described in the preceding paragraphs, shows a definite qualitative correlation with the changes that theoretically take place in the generation and dissipation of energy. In Class I the initial activity is high, but it gradually subsides, as no continuing source of large amounts of energy is available to these objects. Both color indexes respond to this change by moving toward more negative values as the quasars age. In Class II the initial activity develops slowly, as it originates from many small events rather than one big event, and the early values of the B-V index are about the same as those of Class I quasars of medium age. However, the internal energy of the Class II quasars *increases* with age, as additional stars continue to arrive at the destructive limit. The B-V index therefore moves toward more positive values, reaching maximum levels in the redshift range from 1.00 to 1.40 that are comparable to those of the early Class I quasars.

Beyond 1.40 redshift the motion of the average quasar undergoes a change, the readjustment that is responsible for the appearance of absorption redshifts, which are present in most quasars beyond z = 1.40 but are relatively rare at the shorter distances. Inasmuch as this change, which distributes a somewhat greater total energy over a larger number of motions, reduces the energy *concentration*, the B-V index drops to a level approximating that of the early members of Class II. The U-B index does not seem to be sensitive to the events that take place in the evolution of the Class II quasars, and, as stated earlier, shows no systematic change.

At the time *Quasars and Pulsars* was published it did not appear that the available observational information regarding the internal structure of the quasars was extensive enough or accurate enough to justify any attempt at a theoretical explanation of the various structural features. Of course, the theoretical conclusions are independent of empirical information, and it would be possible to proceed with the deductions from theory in advance of the observations, but, as a practical matter, there is not much to be gained by arriving at theoretical answers to outstanding questions unless (1) the theory is already firmly established, or (2) enough observational data are available to enable a demonstration that the theoretical results are in accord with the physical facts. It cannot be claimed that the Reciprocal System of theory is, as yet, firmly established in the eyes of the scientific community (although there is abundant evidence to prove its validity when that community gets around to examining it in detail), and the policy that has been followed in the development of the details of the theoretical system has therefore been to confine the work to phenomena on which enough information is available to verify the validity of the theoretical conclusions that are reached. However, the situation in the observational area changes as time goes on, and inasmuch as the scope and accuracy of the observations of the structural features of the quasars have been substantially improved in the last few years, a preliminary theoretical consideration of this subject would seem to be in order at this time.

It is clear, from a theoretical standpoint, that the factor which determines the internal structure of the quasars is the existence of two quasi-independent populations of stars and particles. At the time of ejection, the quasar as a whole is moving at a speed in excess of that of light, although the spatial speed relative to our location is, for the time being, reduced to a level below that of light by the opposing gravitational motion. The violence of the ejection has also had an effect on the individual speeds of the material aggregates within the quasar, and some of the constituent stars and particles are now moving at ultra-high speeds, while others retain the lower speeds that prevailed while the object that is now a quasar was still a part of the outer structure of the galaxy of origin. There is some contact between these two populations, but the contacts are minimal, for reasons explained in earlier publications, and energy equilibrium is established for each population independently. At this early stage of its development, therefore, the quasar is a two-component system, with ultra-high particle speeds in one component and speeds less than that of light in the other.

In order to understand the consequences of the existence of these two dissimilar components a consideration of the theoretical background will be necessary. According to the postulates of the Reciprocal System of theory the physical universe is composed *entirely* of motion, that term being used in what we may call the scientific sense, which defines it as a relation between space and time, measures it as speed or velocity, and represents it in mathematical symbols by the "equation of motion." In its simplest form that equation is $v = s/t$. Only two physical restrictions are placed on motion by the postulates: (1) that it is limited to three dimensions, and (2) that it exists only in discrete units.

In such a universe, where there is *nothing but* motion, space and time have no significance other than their status as the two reciprocal aspects of that motion. At the basic level, where no physical activity is taking place and nothing exists but individual units of motion, each such unit is a relation between one unit of space and one unit of time. In their capacity as the reciprocal aspects of these units of motion, the only significance that they possess, the *units* of space and of time are therefore *moving* units. Consequently, the natural reference system, the datum from which all physical activity extends, is not a stationary system, as heretofore assumed; it is a *moving* system. In the absence of physical activity the universe is not at rest; it is in motion at unit speed. Every location in the physical universe, together with any object that may be occupying such a location, is continually moving outward from every other location at this speed: one unit of space per unit of time.

This substitution of a moving system of reference for the familiar stationary reference system is the first of the major conceptual revisions that are required in order to view physical phenomena in the context of a universe of motion. Mental reorientation of this nature is, of course, difficult. As Herbert Butterfield puts it, "Of all forms of mental activity, the most difficult to induce... is the art of handling the same bundle of data as before, but placing them in a new system of relations with one another by giving them a different framework." But there is no alternative. Where science has been looking at physical phenomena in the wrong way, the prevailing viewpoint must be altered before the picture can be seen in its true light.

The way in which the concept of a moving system of reference gives us an altogether different view of many physical relations is well illustrated by its application to the recession of the distant galaxies. According to conventional theory, an object at rest in the universe is motionless with respect to a stationary reference system. In order to explain the recession on this basis it is necessary to provide some means whereby the galaxies could have been accelerated to their present speeds, and since there is no known process that is anywhere near adequate for this purpose a most extraordinary event has been postulated, a catastrophic "big bang" that has hurled the galaxies out into space. In a universe of motion, on the other hand, the recession is a direct result of the basic nature of the universe, and the only thing that needs to be explained is the lower recession speed of the closer galaxies.

This explanation does not require an implausible *ad hoc* assumption such as that which is the basis of the "big bang" hypothesis. The lower speed at shorter distances is the result of a retarding effect that we *know* is present, that of gravitation. As shown in detail in *Quasars and Pulsars* and previous publications, gravitation in a universe of motion is an inherent property of the combinations of motions that we recognize as matter, and is itself a motion (as, of course, it must be) similar to the recession in its general nature, but negative rather than positive. The net effective motion of any object is therefore determined by the relative magnitudes of the opposing inward and outward motions. In our immediate environment gravitation predominates, but inasmuch as its effect decreases with distance there is a point beyond which the net motion is outward, and the more distant galaxies therefore recede from our location at speeds that increase with distance, reaching a major fraction of the speed of light at the extreme range of present-day instruments.

As can be seen from this explanation, the recession is inherently a *scalar* motion, simply outward. Gravitation is an inward motion of the same character. The approximate equality between these two opposing motions that exists in our local environment makes it possible to set up an arbitrary reference system in which measurements are made from a zero motion base. Such a reference system enables recognition of the three-dimensionality of physical existence, and makes it possible to assign spatial *directions* to the inherently scalar recession and gravitational motion (as well as to other more complex motions that are inherently vectorial). However, this stationary three-dimensional spatial reference system does have a serious defect in that it is limited to the representation of spatial positions, and provides no means whereby changes of position in time can be taken into account. In utilizing it we are therefore tacitly assuming that no such changes occur, other than those due to the omnipresent time progression. The results obtained on the basis of this assumption are accurate at low speeds, where changes in time location relative to the natural moving datum are negligible, but serious discrepancies are introduced at high speeds (this is the origin of the difficulty that the relativity theory was designed to overcome), and the reference system breaks down altogether in application to speeds beyond the unit level (the speed of light). There is no way in which such speeds, or the changes in location that result therefrom, can be represented in a three-dimensional coordinate system.

The concept of phenomena which either cannot be represented accurately, or cannot be represented at all, within a three-dimensional spatial system of reference, will no doubt be unacceptable to many Individuals who are firmly committed to the long-standing belief that the region defined by such a system is the whole of physical existence. But this is simply another case of anthropomorphism not essentially different from the once general conviction that the earth is the center of the universe. Nature is under no obligation to conform to the manner in which the human race perceives physical events, and in order to enable continued progress toward better understanding of natural processes it has been necessary time and again to transcend the limitations that men have tried to impose on physical phenomena. Extension of physical theory into regions beyond representation in the conventional reference systems is a drastic move, to be sure, but the fact that such an extension turns out to be required when we place our system of theory on the sound conceptual foundation provided by the idea of a universe of motion should not surprise anyone who is familiar with the history of science.

The salient point here is that because it is a universe of motion, with all of the latitude that is made possible by the versatility of the motion concept, the physical universe is much more extensive than the reference system into which conventional scientific thinking tries to force it. Of course, there is no *a priori* reason why the physical universe must necessarily be a universe of motion. But a development of the consequences of the postulates that define such a universe has demonstrated that these consequences are completely in accord with the observed properties of the physical universe, thereby establishing that this physical universe is, in fact, a universe of motion. Naturally, the change from the definitely untenable concept of a universe of matter to that of a universe of motion calls for some modification of fundamental ideas, and in order to gain a clear understanding of the new theoretical picture the various features thereof must be viewed in the context of this "different framework," as Butterfield calls it. The first essential is to relate all basic physical phenomena to the moving, rather than the stationary, system of reference.

A major result of this change of reference system is elimination of the infinities that appear when present-day physical theories are carried to their limits. These infinities are the despair of the physicists. "We have all these nice principles and known facts, but we are in some kind of trouble," says Feynman (*The Character of Physical Law*, 1965), "either we get the infinities or we do not get enough of a description." He recognizes that *something* in current thought must be wrong, and he can see that the error probably lies in some basic assumption, but he admits that he and his colleagues are at a loss to say what it actually is: "We really do not know exactly what it is that we are assuming that gives us the difficulty producing infinities." The finding that the natural system of reference in the physical universe, a universe of motion, is a *moving* system now provides the answer to this "nice problem," as Feynman calls it. The conceptual error that is causing the difficulty, the erroneous assumption that underlies conventional physical theory, is the assumption that the datum from which physical activity extends is zero. The infinities result from this error; they are man-made. They do not exist in nature, because nature knows neither zero nor infinity (other than the *net* resultant of zero that is produced by the interaction of equal and opposite motions). Physical activity in a universe of motion is limited to the range from 1/n to n/1. Zero, 0/n, and infinity, n/0, are both physically impossible, as neither time without space nor space without time can exist in a universe in which there is *nothing but* motion.

Another of the major conceptual changes that are necessary in order to comprehend what happens in a universe of motion is a revision of previous views as to the relation between space and time. In motion, these two entities are reciprocally related, as expressed in the equation of motion, $v = s/t$. Where nothing but motion exists, this is a *general* relation; that is, space and time are reciprocally related *everywhere* in a universe of motion. Since all physical entities and phenomena in such a universe are motions or combinations of motions, they are combinations of space and time in different ways and in different proportions. One of the important consequences of the general reciprocal relation is that for each of these entities or phenomena there exists another that is exactly the same in all respects except that space and time are interchanged. Inasmuch as unity is the boundary between n and its reciprocal 1/n, it also follows that the space-time relations are inverted whenever and wherever this boundary is crossed in either direction.

Lack of recognition of this inversion at unit levels is responsible for many errors in conventional physical theory, and is one of the principal reasons why science has not been able to achieve the same degree of success in dealing with recent discoveries in the realms of the very small, the very large, and the very fast that has characterized the results in the more familiar regions of the universe, which are within the unit boundaries and therefore not subject to the inversions. In most cases, the physical effects of the inversions have been observed, but they have been misinterpreted. The current belief that speeds in excess of the speed of light are impossible is a typical example. In a universe of motion, the true explanation is not that a speed of unity (the speed of light) cannot be exceeded, but that the space-time relations of the physical phenomena related to the speed are inverted at the unit level. A *spatial* speed greater than that of light is impossible, not because there are no greater speeds but because the greater speeds are *temporal* speeds; that is, they cause change of position in time rather than change of position in space.

A similar inversion is responsible for the generation of radiation at radio frequencies in the quasars and related objects. In order to avoid the confusion that might result from introducing too many unfamiliar ideas at the same time, the source of this radiation was not identified in the discussion in the earlier pages, other than by the rather vague expression "internal activity." At this time, however, it is appropriate to point out that the "internal activity" of the quasars is *inverse* radioactivity. The radio flux consists, at least mainly, of inverse gamma rays: radiation with frequency 1/n, where n is the frequency (in natural units) of the corresponding gamma rays. This situation was discussed briefly in *Quasars and Pulsars*, but some additional comments are now in order inasmuch as the problem of accounting for the energy output from the quasars is the most difficult issue facing any theory that undertakes to explain these objects.

No advance at all has been made in this respect by the physicists and astronomers working along conventional lines. The position of conventional theory has, in fact, deteriorated in recent years, as the greater redshifts that have been located imply a still further increase in the maximum energy output, which was already far beyond any possibility of explanation within the bounds of orthodox physics. There is no lack of appreciation of the seriousness of the situation. Simon Mitton, for instance, tells us that, "At the present time, the so- called 'energy problem' (in the quasars) is widely considered to be the most important unsolved problem in theoretical astrophysics." But it gets comparatively little attention in present-day practice, simply because, in the context of current thought, there is no way of even approaching the problem of generating the stupendous amount of energy that appears to be required.

In the context of the Reciprocal System of theory there is no problem. On this basis, the energy requirements are very much lower, as the quasars are not anywhere near as far away as conventional theory would put them, while at the same time the existence of a hitherto unknown source of large quantities of radiant energy is disclosed. Explosions of the kind that occur as Type II supernovae reduce a portion of the stellar material to energy and accelerate most of the remainder to ultra-high speeds. At these speeds beyond the unit level the factors that govern atomic stability are, like all other properties related to the speed, inverted. Under low speed conditions, the zone of stability in the normal galactic environment is above the basic level at which the atomic weight is twice the atomic number. At ultra-high speeds the direction of the mass increment is reversed, and the zone of stability is below the basic level. This makes no difference in the case of a light element, because the deviation of its atomic weight from the basic level is negligible. But for the heavy elements the change is substantial, and radioactive ejection of mass is necessary in order to reach the new zone of stability. Inverse gamma rays (radiation at radio frequencies) are emitted during this process, just as normal gamma rays are emitted during the more familiar radioactivity of the low-speed region.

Thus it is not necessary to assume the existence of exotic physical processes to account for the radio emission from astronomical objects. Wherever Type II explosions occur—in quasars, in the interiors of the giant elliptical galaxies, in the cores of the Seyfert galaxies, in the central portions of smaller and younger galaxies such as our own, and in isolated stars throughout all galactic aggregates—inverse radioactivity takes place and radiation at radio frequencies is emitted. The reason for the dependence of the quasar radiation pattern on the "internal activity" is therefore apparent.

Inversion at the unit level likewise explains the special characteristics of the second unit of quasar motion. When the enormous amount of energy released in a galactic explosion ejects a fragment of the galaxy, a quasar, at a speed in excess of that of light, this involves crossing the boundary of the region of unit speed. Beyond unit speed the quasar is no longer moving in space, but in time. However, the relation between the zero space datum and the zero time datum is such that this motion in time has a specific spatial effect, which has been described in previous publications as a motion in *equivalent* *space*. As therein explained, these two zero levels are separated by the equivalent of eight units; that is, if the time magnitude is one unit, the equivalent space magnitude is seven units. (This is a relation of wide applicability. For instance it accounts for the primary valence pattern in chemical compounds, where an element with a negative (space) valence x, such as sulfur in CS_2, has a positive (time) valence 8 - x, as in SF_6.)

By reason of this relationship, a quasar which passes the unit boundary and acquires a unit of motion in time is moving at a rate of seven units in equivalent space. Half of these seven units are coincident with the normal recession (except near the 2.326 limit, where the distribution of the seven units may be altered, as explained earlier). This coincident portion of the motion in equivalent space does not result in any actual change in spatial position, but it does enter into any phenomenon such as the spectral redshift which is related to the total amount of motion rather than to the spatial motion alone, and it also has a bearing on the amount of movement in space that results from the interaction of the quasar motion and gravitation. This, in brief, is the theoretical basis for the treatment of the external aspects of the quasars in *Quasars and Pulsars*, and in the previous pages of this extension of that work.

Now we are concerned with the internal aspects, and the first significant point that comes to light is that, in its early stages, the quasar contains two distinct components with very different particle speeds. Ordinarily we think of the motions of the constituent particles of an aggregate as being distributed in all directions, so that the effect on the speed of the aggregate as a whole is zero, but vectorial direction has no meaning in application to speeds in excess of unity. All of the components of the total motion of the quasar are purely scalar—simply outward (which is the reason why they produce no blueshifts). Consequently, the difference of one unit between the particle speeds of the two populations within the quasar means that they are moving apart.

Since the quasar as a whole is already moving at a speed of two units, the addition of an internal unit brings the total speed of the faster particles up to three units. As brought out in the previous discussion, the second unit of motion is collinear with the first, and the explosion component of the total quasar speed, $3.5z^{1/2}$, adds to the normal recession speed z. This is possible because a two-unit change in speed, from one unit in the spatial direction (+1) to one unit in the temporal direction (-1) does not result in a net total speed in excess of one unit at any point, and hence such a change is within the limitation imposed by the discrete unit postulate. But the existence of more than two collinear units would conflict with that postulate, and is therefore excluded. Hence the third unit of motion, the level of the individual motions of the stars and particles that constitute the ultra-high speed component of the quasar, is necessarily perpendicular to the line of the recession, and instead of manifesting itself as an additional outward motion in our reference system (an addition to the redshift) it appears as a lateral displacement.

In the context of our three-dimensional frame of reference, the lateral displacement acquires a direction, but the reference system only identifies the line of motion, and does not specify which way the object is moving along that line. The latter, so far as the reference system is concerned, is purely a matter of chance, and since the probabilities are equal, the ultra-high speed material will, in the absence of physical interference, be distributed equally between the two lateral directions.

Because of the inherently non-directional nature of a scalar motion, its apparent direction is relative to the location of the observer. The net magnitude of the observed change of radial position also depends on the observer's location, by reason of the attenuation of the gravitational effect with distance. From our viewpoint, distant galaxy X is receding in a certain direction at a high speed (that is, a high value of the redshift z). To an observer in galaxy A, closer to X, the observed speed of X is lower, and the direction of the motion is totally different, while to an observer in galaxy B, quite near X, galaxy X is not moving at all. The same is true of the observed values of the explosion component of the quasar speed (the second component), which has the same directional characteristics as the normal recession, and differs mainly in the observed magnitude ($3.5\ z^{1/2}$ instead of z).

Now we are considering a third scalar motion that is lateral rather than radially outward, and has a magnitude differing from both of the other recession components. Here, again, the observed speed, and consequently the position, depends on the location of the observer. To us, there is a separation between the ultra-high speed and low speed components, and the quasar appears as three objects (one optical and two radio) in line, whereas to the nearby observer in galaxy B there is no separation. He sees only one object. The basic principle that governs this situation is that, in observing scalar motion, either radial or lateral, the observer sees only the net difference between the actual outward motion of the observed object (away from the observer) and his own inward gravitational motion (toward the object), the magnitude of which varies inversely with the distance. It should be noted that from the scalar standpoint the lateral displacement is outward, and the inward motion of gravitation opposes this displacement in the same manner that it opposes the outward radial motion. This is another of the places where the conventional three-dimensional system of reference is not capable of giving us a true picture of the actual situation.

All of the radiation from the quasar is subject to the same considerations, but the optical radiation comes mainly from the low speed matter, and the radiation at radio frequencies comes mainly from the ultra-high speed matter. The optical observations therefore see the quasar at the undisplaced location, while, in the simplest situation, where there is a fairly complete separation of the components, the radio observations see it in two areas that are equidistant from the center of mass and diametrically opposite each other. In this case the total radio emission is divided equally between the two outlying locations.

Since the segregation of the two components is usually incomplete, and may be very irregular, deviations from this simple pattern are common. If enough of the ultra-high speed matter remains intermingled with the low speed aggregate to result in an appreciable radio emission from the optical location, or if there is a significant emission in the radio range from the low speed matter itself, the radio observations show three emission sources in line, rather than merely a double source. The prevalence of this pattern is indicated in the data reported by Macdonald and Miley (*Astrophysical Journal*, Mar. 1, 1971). These investigators say that only 6 of the 36 quasi-stellar objects for which they determined radio structures are definitely double, whereas 23 may have a third component at the center. The remaining 7 are more complex.

The more complex patterns result from irregularities in the initial distribution of the ultra-high speed matter and from non-central internal explosions. The symmetrical pattern that has been described prevails only where the center of mass of the ultra-high speed component coincides with the optical center, and any irregularities of the kind mentioned can therefore cause a deviation of the radio centroid from its optical counterpart. If the explosions are very energetic some rather drastic changes may occur, but more commonly the result is merely a displacement of the radio centroid along the normal lateral line. If the explosive activity is continuing, the matter newly elevated to the ultra- high speed status by the explosive release of energy will move outward to one or both of the normal positions of the ultra-high speed component, but a finite time is required for completion of this movement, and in the interim a jet of material (or perhaps two in opposite directions) will be observed moving outward along the line of the radio sources. Where there are intermittent bursts of explosive activity, concentrations, or “knots,” of matter will be seen in the jets.

Because of the improvement in techniques of observation and measurement of the various structural features of the quasars that has been accomplished during the past few years there is now ample evidence to substantiate the qualitative account of the structural pattern given in the foregoing paragraphs. Enough measurements are also available to enable reaching some conclusions with respect to the most significant of the items that can be evaluated quantitatively: the magnitude of the separation between the two principal radio components.

When a star or particle in the interior of a quasar, which is moving in equivalent space by reason of its participation in the motion of the quasar as a whole, acquires an individual speed in excess of that of light it crosses a second unit boundary, and again an inversion of physical properties takes place. This second inversion brings the motion back into actual space, and the third of the components that make up the total scalar motion of the ultra-high speed aggregates in the quasar therefore has the same general characteristics as the normal recession. It is, however, subject to limitations because of its position as the *third* unit. Only a relatively minor part of its total magnitude is effective in the region below unit speed, and the spatial displacement that it causes is correspondingly small. (Like the 8-x space-time equivalence previously discussed, this inter-regional asymmetry is a principle of wide applicability. For example, it enters into the determination of such physical quantities as the coefficient of thermal expansion and the inter-atomic distance, the study of which led to the original formulation of the Reciprocal System of theory.)

The explanation of the asymmetry lies in the fact that motion in time and motion in space are coincident only at the unit level. This is essentially no more than a point contact, and motion in one region can be transmitted to the other only through the medium of those units of motion that are specifically directed toward the point of contact. As brought out in previous publications, one out of every eight units of a linear motion in space is effective in the adjoining time unit (or vice versa). A reduction of this magnitude thus takes place between the third unit of speed (a spatial unit) and the second unit (a temporal unit). Here a still greater reduction is effective, as there is no requirement that the motion transmitted from unit three be restricted to the dimension in which it will be in contact with unit one, the spatial region below the speed of light. In the absence of such a restriction, the motion is distributed over all three dimensions of the time unit (unit two), and only one unit out of every 8^3 is passed on to unit one.

One third of the latter amount is visible in each of the three dimensions of the low speed region, and we therefore arrive at the conclusion that where the normal speed of recession is z, the two radio components of a quasar (the ultra-high speed components) are separated by * distance z/(3 x 84) = 8.4 x 10^{-5} z. The natural unit is equal to radians at z = 1.00, and in terms of seconds of arc, the conventional unit in which the measured separations are expressed, this becomes 16.8 z. Inasmuch as the *observed* length of any separation is inversely proportional to the distance z, the foregoing result tells us that the observed separation between the two radio components should be constant for all quasars of early or medium age (those which have not yet reached the stage where secondary explosions are taking place on a large scale) and should be 16.8 seconds of arc. The separations measured by D. E. Hogg (*Astrophysical Journal*, Mar. 1969), together with the deviations from the theoretical separation (excluding those measurements that could not be clearly identified with quasars, and two other values that will be considered later) are shown in the following tabulation:

Table 4: COMPONENT SEPARATIONS

Quasar	Separation	Deviation	Quasar	Separation	Deviation
3C 273	19.6	+2.8	3C 288.1	6.4	-10.4
3C 249.1	18.8	+2.0	3C 208	10.5	-6.3
3C 275.1	13.2	-3.6	3C 204	31.4	+14.6
3C 261	10.8	-6.0	3C 181	6.0	-10.8
MSH 13-011	7.8	-9.0	3C 268.4	9.4	-7.4
3C 207	6.7	-10.1	3C 280.1	19.0	+2.2
3C 336	21.7	+4.9	3C 432	12.9	-3.9
3C 205	15.8	-1.0			

In view of the many uncertainties that are involved, this is probably as close a correlation as we can expect at this stage of the investigation of the subject. The average deviation is 6.3. The observers' estimates of the probable error range from 0.5 to 2.4, but such estimates do not usually take fully into account all of the uncertainties that are inherent in the methods and the assumptions that are utilized. The results obtained by Kapahi, *et al* (*Astronomical Journal*, Oct. 1973) are similar to those of Hogg, and it is interesting to note that 5 of their 15 measurements fall in the range from 15 to 17, practically on the theoretical target.

The average deviation of the values reported by Macdonald and Miley is considerably larger, but these authors comment that their list includes many objects in which the radio components are so far distant from the optical that, in their words, "If the radio structures of the larger QSSs were not symmetric about the optical QSO they might not have been identified." This suggests that the quasars with the larger component separations represent a different group of objects, the members of which are farther along the evolutionary path, and have undergone some further explosive activities that have given portions of the quasar motions away from the main body. Such a hypothesis is supported by a further comment from the investigators which seems to indicate that, in some instances, both types of component separations are present in the same quasars. "Many sources," they say, "have large scale structure but small scale components dominate." The observed values of the separations are also in agreement with this explanation, as the separations of almost all of those that deviate from 16.8 by any large amount (including the two excluded from the tabulation of the results reported by Hogg) are inversely proportional to the distance, as they theoretically should be if they are the results of secondary explosions of comparable size.

Since the frequency of these secondary explosions (those that occur within the quasar after the original ejection) increases with age, a point is ultimately reached where practically all of the constituent stars and particles have acquired ultra-high speeds by reason of the large amount of energy released. It then follows that because the lateral displacement of the radio components is due to the existence of two distinct populations of stars and particles with very different average speeds, when the low speed component is eliminated the lateral displacement effect terminates. The very old Class II quasars therefore show no spatial extension other than that corresponding to the spatial dimensions of the central objects, and as these are very small they are mainly beyond the resolving power of existing facilities. The list of "unresolved" objects included in the Macdonald and Miley report is, as would be expected from the foregoing, made up principally of Class II quasars that, on the basis of criteria such as the presence of absorption redshifts, large radio emission, and high z values, are in an advanced stage of development.

In this matter of the separation of the radio components of the quasars we again encounter a situation in which the observations definitely *demand* something that conventional theory cannot supply. As expressed by Kellerman (*Astronomical Journal*, Sept. 1972), "e*ither*: The linear dimensions of radio sources depend on red shift in just such a way as to cancel the geometrical effects of the red shift, or: The geometric effect of the red shift on apparent size is negligibly small." Neither of these alternatives can be accommodated within the boundaries of conventional physical theory, and therefore, Kellerman says, astronomy is confronted with a paradox.

But, in fact, this is not a paradox. It is simply a message from nature, and it is the same message that we get from the analysis of the redshifts in Arp's associations. It tells us that inasmuch as the lateral displacements, like the excess redshift, are *directly related* to the recession, and are therefore observable effects of *motion*, the conventional narrow view of motion, which limits it to speeds less than that of light and to effects that can be represented within a three-dimensional spatial system of reference, must be broadened. When we look at this situation in the context of a universe of motion, where we do have the benefit of a broader perspective, there is no paradox. The theoretical separation that exists in such a universe is exactly what Kellerman says the observations show; that is, "the linear dimensions of the radio sources" (the quasars) *do* "depend on red shift in just such a way as to cancel the geometrical effects of the red shift."

The theoretical explanation of the total motion pattern of the quasars may now be summarized as follows: The recession of the galaxies (including the galactic fragments known as quasars) is due to the outward scalar motion at unit speed that applies to all objects at rest in the natural reference system. The excess redshift of the quasars is an observable effect of a second unit of speed imparted to the ejected fragment by the galactic explosion. The lateral displacement of the regions of radio emission within the early type quasars is an observable effect of a third unit of speed that has been acquired by one of the two distinct populations of stars and particles that are present in these quasars. From the *natural* standpoint, there is merely one motion at a speed of three units (three times the speed of light), but because of the limitations of the system of reference to which this motion is customarily related, each of the three units of speed appears to have effects different from those of the others. The motion as a whole is reduced, for a finite period of time, by gravitation, and each of the three units undergoes a proportionate reduction. Consequently, there are definite mathematical relations between the recession and the observed effects of the other two units of speed. Here, again, the new theoretical development gives us a picture of the situation that is in full agreement with the observations, however paradoxical the observational results may seem in the light of orthodox theory.

There are many pitfalls in the way of anyone who attempts to carry out a long chain of reasoning from broad general principles to specific details, and as this is an initial effort at applying the Reciprocal System of theory to the internal structural features of the quasars, it must be conceded that modification of some of the conclusions that have been reached is likely to be necessary as observational knowledge continues to accumulate. However, the general picture of the quasar structure derived from theory corresponds so closely with the information now at hand that there seems little reason to doubt its validity, particularly since that picture was developed easily and naturally from the same premises on which the conclusions reached in *Quasars and Pulsars* regarding the origin, nature, and behavior pattern of the quasars were based.

It is especially significant that nothing new is required to explain either the existence or the properties of the quasars. Of course, nothing *new* can be *put into* a purely deductive theory of this kind. Introduction of additional hypotheses or *ad hoc* assumptions of the sort normally employed in the adjustment of theories to fit new observations is excluded by the basic design of the theoretical system, which calls for deriving all conclusions from a single set of premises, and from these only. But some new principles and hitherto unknown phenomena are certain to be revealed by any new theoretical development of this magnitude, and many such discoveries have, in fact, been made in the course of the theoretical studies thus far undertaken. Such items as those utilized in the foregoing application of the theory to the various aspects of the quasar situation—the status of all physical phenomena as more or less complex relations between space and time, the inversion of these relations at unit levels, the role of time as equivalent space, and the asymmetric transmission of physical effects across unit boundaries—are all new to science. But these are not peculiar to the quasars; they are *general* principles, immediate and direct consequences of the basic postulates, the kind of features that distinguish a universe of motion from the conventional universe of matter, and they were discovered and employed in a variety of applications decades before the quasar study was undertaken. Not even a single new theoretical idea was required either for the original development reported in *Quasars and Pulsars* or for the extension of that development in these pages. *All* of the novel principles deduced from theory and utilized in this work were explicitly set forth in the initial presentation of the Reciprocal System of theory in *The Structure of the Physical Universe*, published in 1959, years before the quasars were even discovered.

Furthermore, the consequences of those general principles in the form of physical phenomena and relations that are now seen to play an important part in explaining the origin and evolution of the quasars were likewise pointed out in detail in that 1959 publication, four years before Maarten Schmidt measured the redshift that ushered in the era of the quasar "mystery." The status of stellar aggregates as structures in positional equilibrium, which permits the building up of internal pressures in the galaxies, and the ejection of fragments; the existence of two distinct divisions of the explosion products, ejected in opposite directions, one moving at normal speed and the other moving at a speed in excess of that of light; the reduction in the apparent spatial size of the aggregates that move at ultra-high speeds; the generation of large amounts of radiation at radio wavelengths from the explosion products; and the eventual disappearance of the high speed material; were all derived from theory and described in the published work, not only long before the discovery of the quasars, but years before any definite evidence of the galactic explosions that produce the quasars was found.

The theoretical development prior to 1959 was not carried far enough to predict the existence of the quasars, but it is certainly correct to say that it predicted the existence of the *class of objects* to which the quasars, on the basis of present knowledge, belong; that is, the ultra-high speed products of galactic explosions. The accuracy with which the Reciprocal System of theory was able to describe phenomena that *had not yet been discovered* is a significant demonstration of the power and versatility of this new theoretical system based on the concept of a universe of motion, and it should provide ample justification for whatever effort is required in order to understand the basic elements of the theory and their application to the subjects under consideration.

In addition to the new information specifically applying to the quasars that has been accumulated during the past three years, some new facts about related objects have also been ascertained, and here, too, the additional information is consistent with the theory. None of these items is conclusive in itself, but as a whole they add considerable weight to the assertion that the theory provides a correct representation not only of the quasars but also of the related phenomena. Perhaps the most important contribution made by the additional information is that it leaves little room for doubt that these phenomena are, in fact, related to the quasars, and it thereby calls for an explanation of the nature of that relation, a need that has been met in *Quasars and Pulsars*.

As noted in that work, theoretical considerations indicate that a large proportion of the quasars should appear almost directly in front of the galaxy of origin or almost directly behind it. When the quasar is behind the galaxy its radiation is absorbed and reradiated, so that what we should observe is a galaxy with a very prominent nucleus. The distinguishing feature of the N-type galaxies is a nucleus of this kind, and it was tentatively concluded in the previous publication that this class of observed objects could be identified with the galaxies that are theoretically occluding the quasars. This finding has now been strengthened by observations indicating that "the spectra and colors of quasars are similar to those of the nuclei of N galaxies" (*Science*, Sept. 21, 1973).

A substantial number of cases have been found in which a quasar appears to be superimposed on an ordinary galaxy, and this has led to a suggestion that all quasars may simply be N-galaxies with very prominent nuclei. As can readily be seen, however, the theory that requires some quasars to be behind the galaxy of origin, giving rise to N-galaxies, also requires others to be in front of the galaxy of origin. While most such quasars will overpower the radiation from the galaxies and will appear to be alone, it is obviously possible that in some instances evidence of the existence of the accompanying galaxy may be observable, particularly at the shorter distances. In this connection it should be noted that one observer, Jerome Kristian, mentioned that some of the quasars of this class that he studied were "off center" with respect to the underlying galaxies. This is rather difficult to explain on the basis of the N-galaxy hypothesis, but it is, of course, easily understood if what is being observed is a quasar almost directly in front of the galaxy of origin.

Another observation that has been interpreted as evidence in favor of the N-galaxy hypothesis is a change of three magnitudes in the emission from the galaxy X Comae, which leads the observers (Bond and Sargent, *Astrophysical Journal Letters*. Nov. 1, 1973) to conclude that this is "an object that apparently can change temporarily from an N-type galaxy to a QSO." This, they say, "clearly supports the hypothesis that quasars are simply very bright galactic nuclei." However, the explanation provided by the theory presented in this work is not only equally consistent with the observations, but also explains how and why the change takes place, something that is conspicuously lacking in the N-galaxy hypothesis. If the quasar is behind the galaxy from which it was ejected, it is quite possible for changes to occur, as that galaxy rotates, in the amount of matter through which the quasar radiation must pass. Such changes are probably no more than minor in the usual case, but they obviously can extend all the way from a condition in which the entire quasar radiation is absorbed and reradiated, so that we see an N-galaxy, to a condition in which that radiation passes through essentially unchanged, and we see a quasar.

A large amount of attention has been centered on the Seyfert galaxies, and it is now generally agreed that there is sufficient evidence to show that there are "periodic explosions in the Seyfert nucleus that blast debris into the surrounding regions" (1973 *Yearbook of Astronomy*). But "all models of Seyfert nuclei ultimately rely on the *ad hoc* existence of a primary energy source," and "conventional concepts of nuclear physics are woefully inadequate in accounting for such a large energy output from such a minuscule region" (*Ibid*.). The theory developed in *Quasars and Pulsars* explains where the energy comes from, why it emanates from a region of such small spatial dimensions, and why these Seyfert explosions do not produce quasars. All of the new evidence is in agreement with this explanation.

The additional confirmation of the existence of high speed gas motions in the cores of the Seyfert galaxies, and of "periodic explosions" in these objects, intensifies the problem that conventional physical and astronomical theory faces in attempting to account for the build-up and containment of the very energetic material in the interior of a galaxy until the time of the explosion. As R. J. Weymann pointed out in a statement quoted in *Quasars and Pulsars*, conventional theory has no way of explaining this containment. This, then, is another of the places where the Reciprocal System of theory, by providing an explanation, is simply filling a conceptual vacuum.

Like the items which confirm the existence of a build-up of energy, and of periodic explosions, in the Seyfert galaxies, some other recent observations have also given added support to the feature of the theory which says that all of the very energetic events that are taking place in galactic nuclei, all the way from the relatively mild activity in galaxies such as our own, through the intermediate Seyfert type, to the tremendous explosions in the giant elliptical galaxies that produce the quasars, have the same origin and the same general nature, differing only in magnitude. It has been shown by Fath, et al, (*Astronomy and Astrophysics*, April (I) 1973) that the amount of radio emission (which is an indication of the extent of the explosive activity) is related to the brightness, and hence to the size, of both spiral and elliptical galaxies, as the theory requires. Also "the underlying galaxy (of the N-system) has the same colors as a giant elliptical (E) galaxy" (*Science*, Sept. 21, 1973), an observation that tends to support the theoretical finding that this "underlying galaxy" is a giant elliptical that exploded and ejected a quasar.

In early 1971, after *Quasars and Pulsars* had gone to press, a flurry of excitement was generated by a report from a group of investigators at MIT which appeared to indicate that speeds somewhere in the neighborhood of three to ten times that of light had been observed in a quasar. Typical of the reaction was a caption in the *New Scientist* which read "Enigmatic Redshifts Cause Cosmic Chaos." The initial impact of this discovery has been softened by the passage of time, but there is still no satisfactory explanation of the observations on an orthodox basis. Indeed, as long as the validity of the observational results remains unchallenged, these observations constitute a powerful argument against the cornerstone of the orthodox position, the cosmological redshift hypothesis. Spatial speeds greater than that of light are equally as impossible in the context of the Reciprocal System of theory as in conventional physics (the ultra- high speeds involve motion in time rather than in space) but no problem arises when the observations are interpreted in the light of this new system, as the substitution of the "intermediate" for the "cosmological" explanation of the redshifts reduces the indicated speed to an acceptable value.

This concludes the discussion of those of the new items of information which, as matters now stand, appear to have a bearing on the question to which this review is addressed: the question as to the accuracy of the conclusions reached in *Quasars and Pulsars*. The facts brought out in the preceding pages make it evident that the theoretical explanation of the quasars derived from the Reciprocal System of theory is in full accord with all of the information that has been gathered during the past three years. Even those conclusions that were specifically designated as "tentative" in the original discussion still stand. This is a graphic illustration of the great advantage of having a purely deductive theoretical structure that contains no empirical elements, and is therefore capable of arriving at the correct answers not only in the familiar regions of the universe, where factual information is plentiful and accurate, but also in relatively new areas where the available observational data are meager and not wholly reliable.

In striking contrast, conventional physical theory has been faced with one serious problem after another where attempts have been made to apply it to the new astronomical areas, and recognition of its inability to deal with the quasars and some of the other classes of recently discovered objects has been growing rapidly during the past few years. One of the first to voice his dissatisfaction publicly was Fred

Hoyle. In the George Darwin lecture given to the Royal Astronomical Society in 1968, Hoyle sounded a clear call for a "radical revision of the laws of physics." As reported in the *New Scientist* of Oct. 17, 1968,

> Professor Fred Hoyle was convincing about the total inadequacy of conventional physics to account for the behavior of many of the recently discovered objects in the universe.

Three years later, in an article in *Nature*, Sept. 3, 1971, Hoyle, together with J. V. Narlikar, returned to the attack, and stressed the need, not only for a change, but for a *major* change.

> We wish to emphasize the need for a thoroughly radical assessment of the (redshift) problem, considering it unlikely that a satisfactory theory will be achieved by a small change in our concepts.

Here are some of the more recent comments by other observers:

> Clearly, the physics of radio galaxies and quasars, the nature of the red shift, and perhaps fundamental physics itself are being questioned by these measurements (recent radio observations). (K. I. Kellerman, *Physics Today*, Oct. 1973)
>
> But physically we know the least about these peculiar objects (quasars, etc.) and they are the ones for which there is the greatest a priori chance that new and unknown physical mechanisms are at work. (Halton Arp, *Science*, Dec. 17, 1971)
>
> Physics and Astronomy: Unexpected Results May Require New Concepts. (Caption of article in *Science*, Dec. 28, 1973)
>
> It is believed by some that the final solution (to the energy problem in the quasars) will only come after astronomers have rewritten some of the laws of physics. (Simon Mitton, *Astronomy and Space*, Vol. 1)

In these statements some of the prominent figures in the astronomical world are asserting that the present situation in astronomy requires a drastic modification of basic physics; not merely "a small change in our concepts" but something "radical" that will introduce hitherto "unknown physical mechanisms" that are capable of accounting for the phenomena that cannot be explained by conventional theory. Now a new system of theory that meets these specifications has made its appearance. This theory makes only *one* basic change—it changes the prevailing concept of the general nature of the physical universe—but the necessary consequences of this one change introduce the new physical mechanisms that are essential for an understanding of the quasars and other "mysteries" both in astronomy and in physics. In other words, this new theory is just what Hoyle, *et al*, have been asking for, both in its general nature and in its results. In fact, the results actually go a big step beyond the astronomers' demands, as this new development gives them (and the physicists as well) a purely deductive theory, one in which all conclusions in all fields of physical science are derived from a single set of basic premises.

Of course, this theory upsets some cherished physical and astronomical ideas and beliefs, but obviously this is part of the price that must be paid for *any* revision of basic concepts that is drastic enough to produce the required results (if being forced to abandon erroneous ideas can legitimately be classed as a price).